Testing the global capabilities of the Antelope software suite: fast location and mB determination of teleseismic events using the ASAIN and GSN seismic networks

D. Pesaresi[1,2], M. Russi[1], M. Plasencia[1], and C. Cravos[1]
(1) Ist. Naz. di Oceanografia e di Geofisica Sperimentale (OGS), (2) Ist. Naz. di Geofisica e Vulcanologia (INGV)
dpesaresi@inogs.it

Centro di Ricerche Sismologiche

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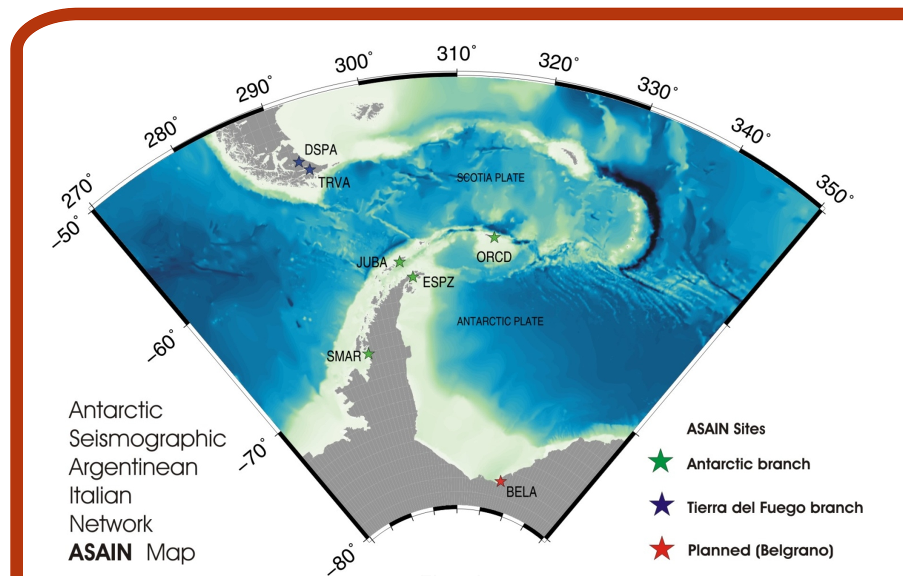


Fig. 1

The Centro di Ricerche Sismologiche (CRS, Seismological Research Center, http://www.crs.inogs.it/) of the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS, Italian National Institute for Oceanography and Experimental Geophysics) manages the North-East Italy (NI) Seismic Network. The OGS-CRS also runs the Antarctic Seismographic Argentinean Italian Network (ASAIN, Fig. 1).
The OGS-CRS is using the Antelope software suite for real-time data exchange with neighboring seismological institutions (namely ARSO in Slovenia, ZAMG in Austria, DST and INGV in Italy), rapid location of earthquakes and alerting.

As a test to check the global capabilities of Antelope, we set up an instance of Antelope acquiring data in real time from both the regional ASAIN seismic network in Antarctica and a subset of the Global Seismic Network (GSN, Fig.2) funded by the Incorporated Research Institution for Seismology (IRIS). To locate teleseismic events the facilities of the IRIS Data Management System, and specifically the IRIS Data Management Center, were used for real time access to waveform required in this study. The Antelope location algorithm, based on pre-computed grid search, is known to be very fast.

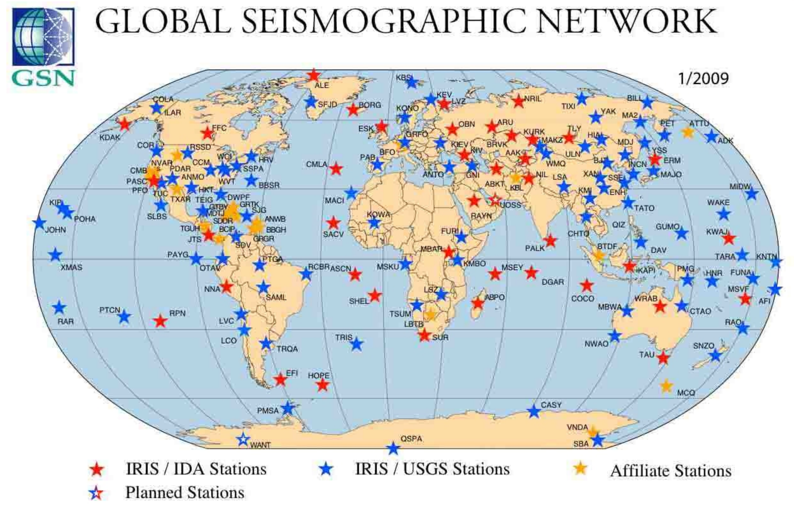


Fig. 2

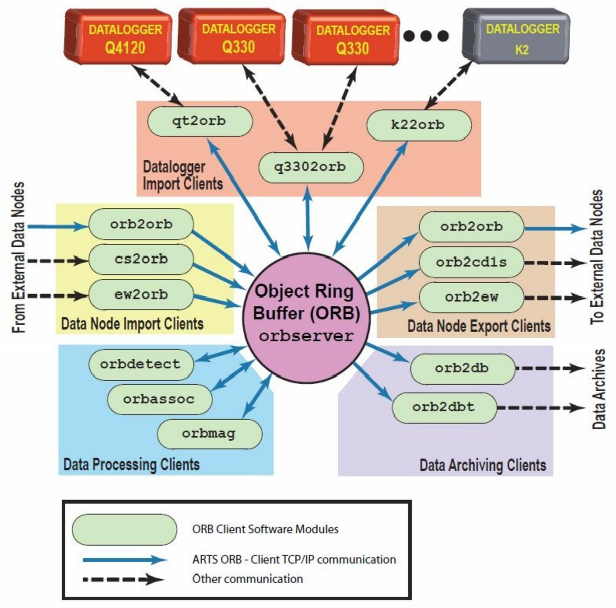
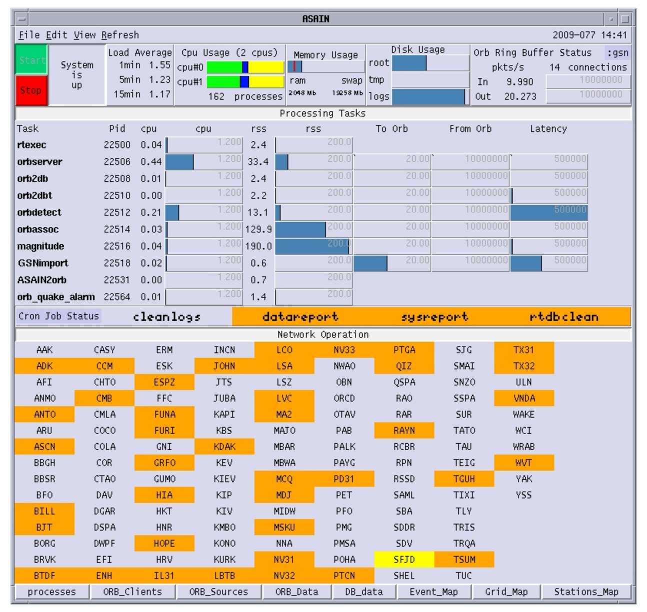


Fig. 3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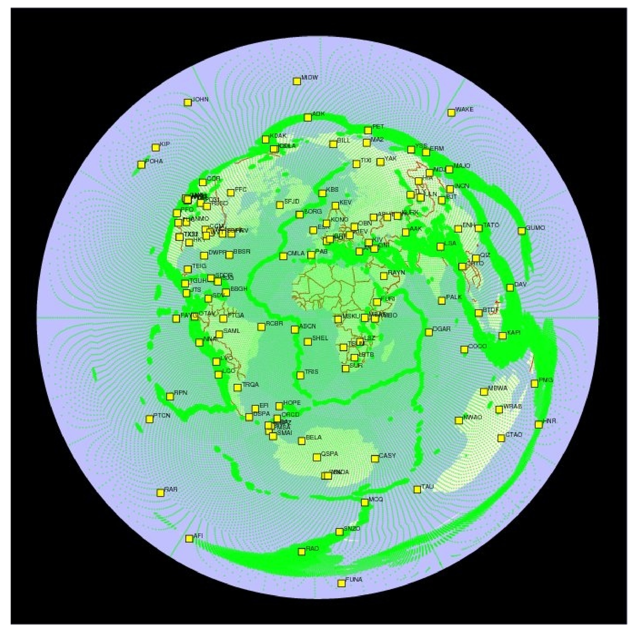
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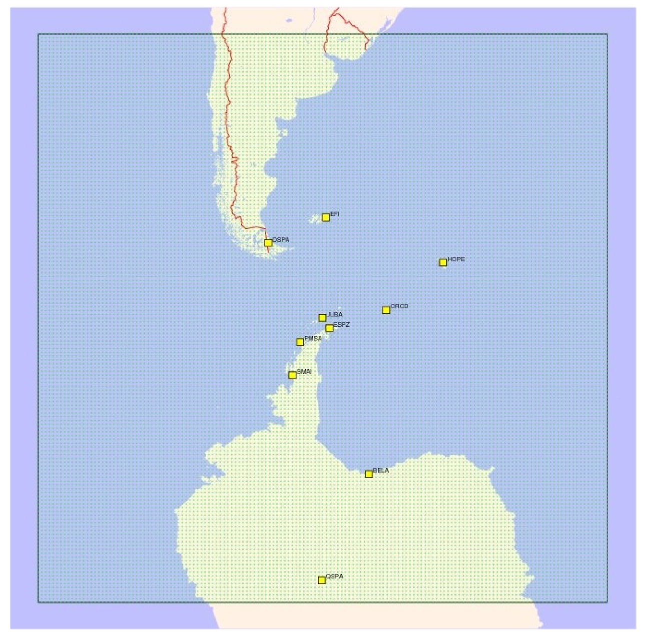
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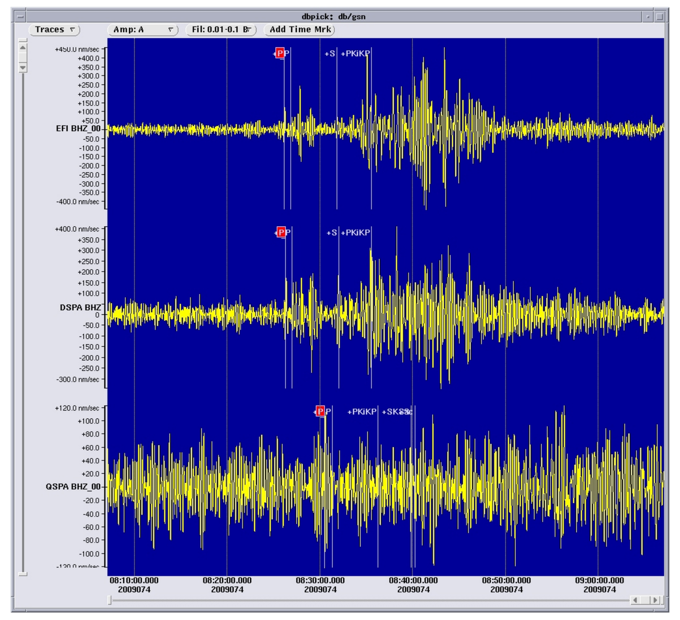
Fig. 7

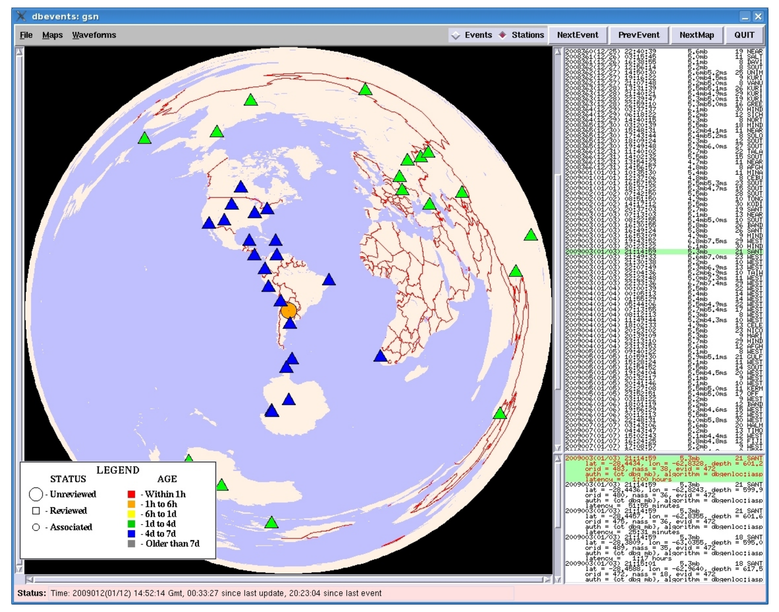
Fig. 8

Figure 3 shows the data flow in Antelope. In the specific test, the *guralp2orb* and *slink2orb* modules were used to import data respectively from ASAIN and IRIS DMC data centers, *orbdetect* to detect events and *orbassoc* to locate them, *orbevproc* to determine mB magnitudes, *orb_quake_alarm* to disseminate alarms via email, *orb2db* and *orb2dbt* to store waveforms and parametric data into the local database.
Fig. 4 shows the real time monitor *rtm* module of Antelope: it gives a quick snapshot of the status of the acquisition, with orange color indicating a problematic issue, and yellow a temporary one. System performances are also metered to allow a complete check of the all system in one snapshot.

Fig. 5 shows the global grid of pre computed travel times for teleseismic events. The grid is more dense in areas of high seismicity like the plate boundaries. Yellow squares indicates the set of ASAIN + GSN seismic stations.
Fig. 6 shows the grid devoted to regional seismicity in the Scotia region in Antarctica and in the South of Argentina, the area monitored by the ASAIN seismic network. The grid is scaled in density according to the reduced size of the area. Again yellow squares indicate the ASAIN seismic stations plus the subset of the GSN seismic station used for this study.
Fig. 7 shows the automatic pickings of Antelope: the specific example is relative to a mB=5.3 event about 40° distant from the ASAIN network. Data is 0.01-0.1Hz bandpass filtered and actual and predicted phases arrivals are shown. Given the low signal/noise ratio, automatic Antelope pickings are performing well.
Fig. 8 shows the Antelope catalog with automatic locations complete of time and mB magnitude estimates. The blue triangles in the map are the seismic station of the ASAIN and GSN networks defining the specific locations, while the green ones are stations just contributing but not defining (residuals too high).

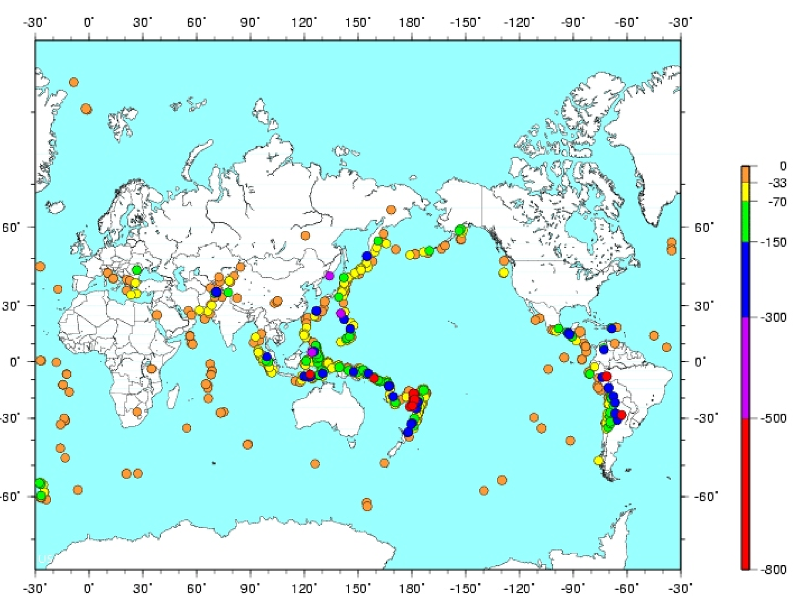
Fig. 9

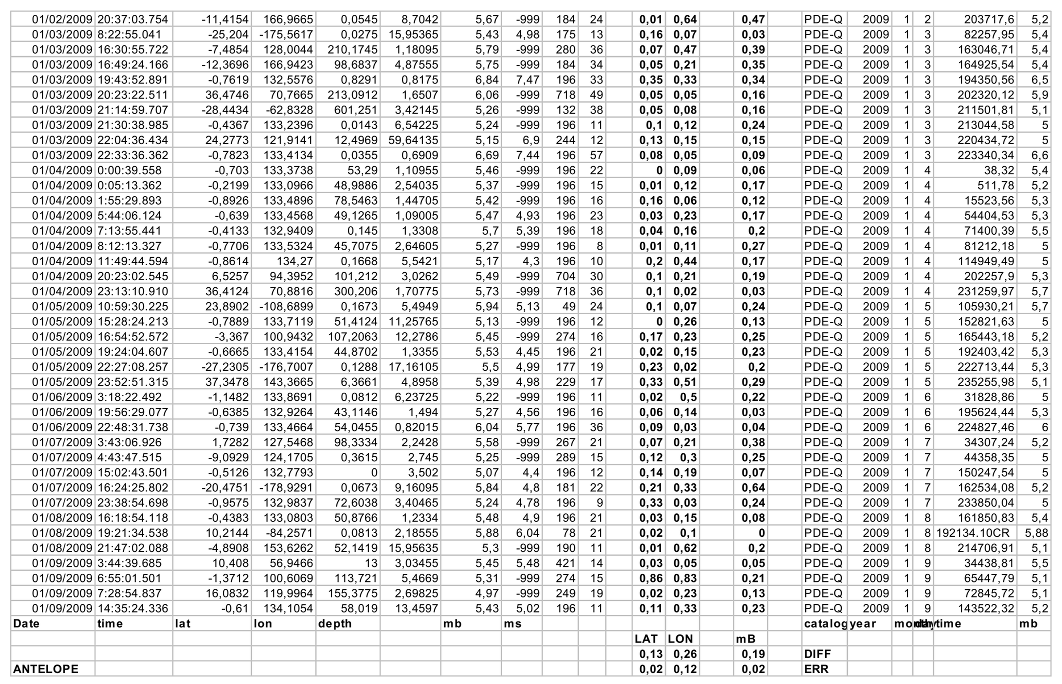
Fig. 10

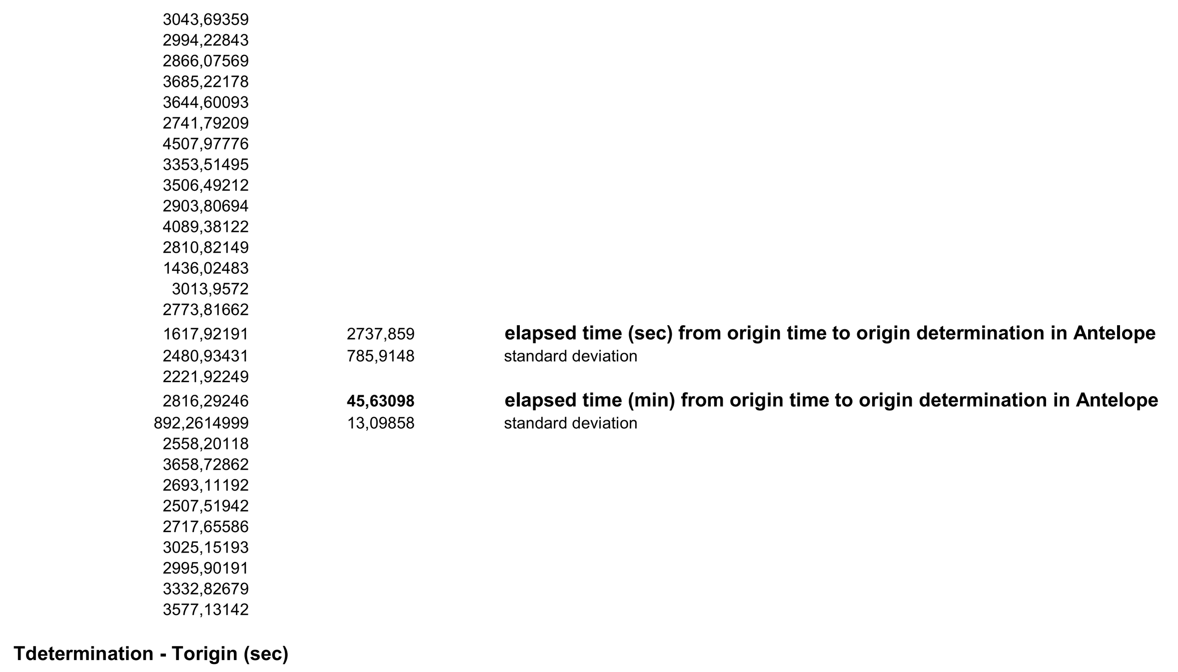

Fig. 11

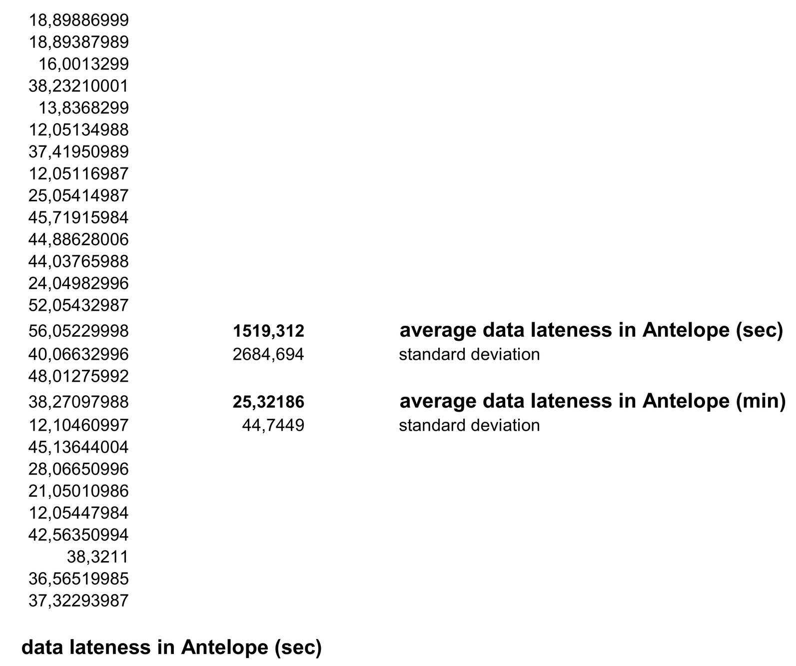

Fig. 12

Figure 9 shows the National Earthquake Information Center (NEIC) Preliminary Determination of Epicenters (PDE) world-wide catalog for the test period, i.e starting from December 19, 2008. Only events with magnitude > 5 were selected.
The data set then has been compared for the same period with the Antelope database (Fig. 10). The two catalogs coincide for more than 90%. It has been then analyzed the Antelope location capability by comparing latitudes and longitudes of the locations in the 2 catalogs. The difference is of **0.13** ± 0.26 in latitude and **0.02** ± 0.12 in longitude. mB magnitude comparison leads to a difference of **0.19** ± 0.02. Given the magnitude intrinsic uncertainty of 0.3 the result is very good.
Fig. 11 shows the time differences between the time each location was actually stored in the Antelope database and origin time of the event itself. The average is **46** ± 13 minutes.
In Fig. 12 we then evaluate the actual data lateness in Antelope, defined as the time difference between the actual time a waveform segment was actually written in the Antelope database and the time of the last sample in the waveform segment itself. The average time difference is **25** ± 45 minutes.
Comparing these measurements with the IASPEI91 P-wave travel time for 180 degrees distance (20'), gives a determination of **2** ± 46 minutes as the time required by Antelope to determine a teleseismic location, which makes of Antelope a serious candidate for global early warning.

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